Submitted to:
US EPA Region 8
Denver, CO

Submitted by:
Atlantic Richfield Company
Anchorage, AK
June 20, 2011

Sampling and Analysis Plan For Surface Water Sampling

Rico-Argentine Mine Site – Rico Tunnels Operable Unit OU01 Rico, Colorado

Atlantic Richfield Company

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June 20, 2011

Mr. Steven Way
On-Scene Coordinator
Emergency Response Program (8EPR-SA)
US EPA Region 8
1595 Wynkoop Street
Denver, CO 80202-1129

Subject: Sampling and Analysis Plan (SAP)
Rico-Argentine Mine Site – Rico Tunnels
Operable Unit OU01 Rico, Colorado

Dear Mr. Way,

Please find enclosed three (3) copies of the revised *Sampling and Analysis Plan* dated June 20, 2011; in addition, an electronic copy of this document in pdf file format is being submitted via email. Atlantic Richfield is submitting the revised document to respond to comments received from EPA by email dated May 27, 2011, and in accordance with the Removal Action Work Plan, Rico Project – Rico Soils and St. Louis Ponds Rico, Colorado dated March 9, 2011.

If you have any questions, please feel free to contact me at 406.491.1129.

Sincerely,

Chuck Stilwell

Chuck Stilwell, P.E.
Project Manager
Atlantic Richfield Company

Enclosures

cc: R. Halsey, AR
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SAMPLING AND ANALYSIS PLAN
FOR
SURFACE WATER SAMPLING
RICO, COLORADO

June 20, 2011

1.0 Introduction

This Sampling and Analysis Plan (SAP) delineates surface water and St. Louis Tunnel water quality sampling and flow measurement activities within the upper Dolores River basin near the Town of Rico, Colorado. The sampling locations and parameters for analysis for this supplemental sampling program have been selected to respond to the requirements identified in the Removal Action Work Plan established by EPA, Region 8 (March 9, 2011). These locations will provide additional data on the St. Louis tunnel discharge, flows at selected locations within the St. Louis settling ponds system and at the system discharge to the Dolores River (collectively referred to as the St. Louis ponds system), and previously sampled locations along the mainstem Dolores River above, at and below the St. Louis ponds system. Water flow measurements will be performed at each sampling site in conjunction with the water quality sampling. Table 1 lists the sampling station locations and site descriptions. Figure 1 illustrates the location of the various sampling stations.

These sample locations were sampled at several intervals from 2003 through 2006 to develop data for the Water Quality Assessment for the Colorado Department of Public Health and Enviromnent (CDPHE). Atlantic Richfield (AR) is also interested in determining the current water quality for these locations in order to update the Water Quality Assessment, if necessary, to establish discharge and receiving water quality data to support the ongoing review of the CDPS discharge permit application and associated permit limits to be developed. This sampling program will also provide discharge water quality data to support system design for treatment of the tunnel effluent.

2.0 Sampling Objectives/Frequency

The data from the water samples will be used to characterize the water quality of the tunnel discharge, flows within the St. Louis ponds system, and along the mainstem Dolores River (the receiving stream for the ponds system discharge). A primary objective of this sampling program is to collect samples and develop water quality data over an entire annual cycle, including seasonal low-flow periods. The sampling program will also provide data to support design and implementation of an effective water treatment system for the St. Louis Tunnel discharge and to determine the need for mine discharge treatment and/or controls.

The final pond discharge enters a segment of the Dolores River that is described as "the mainstem of the Dolores River from a point immediately above the confluence with Horse Creek to a point immediately above the confluence with Bear Creek" in Colorado state regulations, 5 CCR 1002-34, Regulation No. 34.6(4). These regulations establish classifications and water quality standards for streams in the San Juan and Dolores River Basins. The stream segment associated with the St. Louis Tunnel discharge (stream segment #COSJDO03) is classified for

Cold Water Aquatic Life 1, Class E Recreation and Agriculture uses. These uses determine specific numeric water quality standards for physical, biological, inorganic and metal parameters.

The selection of parameters for water sample analyses was primarily driven by these water quality standards. The data collected will be utilized to determine the impact of the final discharge on the Dolores River's compliance with applicable water quality standards. EPA guidance (40 CFR 136) will be applied in determining sample collection and analysis methodologies and standard QA/QC protocols (such as sample blanks, duplicates and spiking) will also be followed to ensure accuracy and reliability of results. (Please see the project QAPP for more detail.) In addition, the selection of other analytical parameters was based on the need to evaluate water treatment technologies and provide valuable input for the design and operation of the treatment system to be implemented.

Sampling Frequency: AR will initiate sampling in April 2011 and will collect samples on a monthly schedule until at least April 2012. After April 2012 sampling and analyses will continue on a seasonal basis as required in the Removal Action Work Plan for the duration of the Administrative Order on Consent, summarized as follows:

Peak Flow (April/May)
Moderate to Low Flow (October/November)
Low Flow (January/February)

3.0 Water Quality and Flow Measurement Sampling Locations

Water quality samples will be collected from the St. Louis tunnel discharge, flows at the discharge of Pond 15 and Pond 8, at the ponds system discharge to the Dolores River, and at previously sampled locations along the mainstem Dolores River above, at and below the St. Louis ponds system. There will be a total of nine sampling locations within the St. Louis Ponds system and on the Dolores River. The nine stations are named as follows: DR-1, DR-2, DR-3, DR-4, DR-5, DR-6, DR-7, DR-4-SW, and DR-G. Samples DR-1, DR-2, DR-7, DR-4-SW and DR-G are collected from the Dolores River. Samples DR-3, DR-4, DR-5 and DR-6 are collected from the St Louis Tunnel discharge and the pond system.

Samples will be collected starting with the most downstream site and progressing upstream, as feasible given flow and access conditions at the time of sampling (ice cap over river). The Dolores River will be sampled above the St. Louis ponds system, and below all previously sampled adit outfalls, (just downstream of the Silver Swan adit). It will also be sampled above and below the ponds system discharge (above the confluence with Silver Creek), above the Columbia Tailings (below the confluence with Silver Creek), and at the USGS gaging station downstream of the Silver Swan site.

Additionally, a Field Blank and a Duplicate sample will be collected during each sampling event (see QAPP for more details). Flow measurements will be taken at all locations where water quality samples are collected, as water depth, velocity and weather permit.

A detailed description of each sampling station is provided below. Typical flow measurement device/methods used in previous sampling or anticipated for use are also given.

DR-1. Dolores River above St. Louis settling ponds system. The sampling/flow measurement location is on the Dolores River approximately 50 feet upstream of the Rico Ranger Station. Flow measurement by flowmeter.

DR-2. Dolores River immediately above the St. Louis settling ponds system outfall. Sampling/flow measurement location is on the Dolores River just above the discharge outfall, and upstream of the hot tub discharge. The site is located directly adjacent to the thermal discharge which supplies the hot tub. Flow measurement by flowmeter.

DR-3. St. Louis Tunnel discharge at adit entrance. Sampling location is approximately 3 feet inside the cinder block structure at the former adit entrance. Flow measurement by installed 9" flume downstream of the sampling location.

DR-4. Discharge of Pond 15. The sampling location is at the discharge pipe located on the midpoint of the Pond 15 south embankment. Flow measurement by flow meter.

DR-5. Discharge of Pond 8. The sampling location is at the outlet spillway located at the southwest comer of Pond 8. Flow measmement by flow meter.

DR-6. St. Louis settling ponds system outfall to the Dolores River (previous permit Outfall 002). Flow measurement by 9" flume.

DR-7. Dolores River below St. Louis settling ponds system outfall. Sampling/flow measurement location is located just off the entrance road to the St. Louis ponds site where the Dolores River is adjacent to the entrance road. The site is located approximately 75 feet downstream of a large bend in the river that first brings the Dolores adjacent to the entrance road. Flow measurement is by flow meter.

DR-4-SW. Dolores River below Silver Swan. Sampling/flow measurement location is on the Dolores River below the Silver Swan site just downstream of a bend in the river and below a cemetery on the east bank. Flow measurement by flow meter.

DR-G. Dolores River approximately 3.5 miles downstream of the Silver Swan site, at the USGS gauging station #09165000 immediately upstream of the bridge at this location. Flow measurement by flowmeter.

4.0 Sampling and Analysis Parameters and Methods

Water samples will be analyzed for the following parameters:

<u>Field Analyses</u>

pH
Temperature

Electrical Conductivity
Dissolved oxygen

Laboratory Analyses

Aluminum (total and dissolved)
Antimony (total and dissolved)
Arsenic (total and dissolved)
Barium (total and dissolved)
Beryllium (total and dissolved)
Cadmium (total and dissolved
Chromium (total and dissolved)
Copper (total and dissolved)
Cyanide (total and dissolved)
Iron (dissolved and total recoverable)
Lead (total and dissolved)
Magnesium (total and dissolved)
Manganese (total and dissolved)
Mercury (total recoverable)
Nickel (total and dissolved)
Potassium (total and dissolved)
Selenium (total and dissolved)
Silver (total and dissolved)
Sodium (total and dissolved)
Thallium (total and dissolved)
Vanadium (total and dissolved)
Zinc (total and dissolved)

Alkalinity
Hardness (total, Ca, Mg)
Total Dissolved Solids
Total Suspended Solids
Salinity
Calcium (total and dissolved)
Sulfate

All samples will be collected as grab samples. Care will be exercised to collect samples from well-mixed locations, which are representative of conditions within the flow stream. For quality control purposes, one duplicate sample and one field blank will be included in addition to the water samples being submitted to the laboratory for analysis.

Lab-certified plastic bottles will be used to collect all water samples. A 500 mL HDPE bottle will be used to collect a sample for alkalinity, TDS, TSS, and sulfate analyses. A 250 mL HDPE bottle will be used to collect a sample for salinity analysis. Sample water for dissolved metals analysis and potentially dissolved metals analysis will first be collected in a clean plastic 250 mL HDPE bottle, and within ten minutes, filtered through a 0.45μm filter into a sample bottle containing nitric acid preservative. Sample water for total recoverable metals analysis and water hardness will be collected without filtration in a 250 mL HDPE sample bottle containing nitric acid preservative. Sample water for cyanide analysis will be collected without filtration into a 250 mL HDPE sample bottle containing sodium hydroxide preservative.

Field parameters will be measured at the time of sample collection. Field measurement data for pH, temperature, electrical conductivity, and dissolved oxygen will be recorded in a logbook and on sample collection forms. To measure these parameters, an EXTECH Instruments DO610 ExSfik II DO/pH/Conductivity kit will be used. Field instruments will be calibrated each sample day prior to starting work activities and using standard solutions and consistent with manufacture's instructions. Weather parameters including temperature and precipitation will be obtained and recorded in the logbook. Field testing to be performed and equipment will be in accordance with Standard Operating Procedure 2-9.

All sample bottles will be labeled to identify sample number, date and time of collection, type of analysis, and appropriate preservative. In addition, sample analysis/chain of custody forms will be completed and processed at the time of sample collection. Original chain of custody forms will be signed, dated, and placed in the sample shipment container prior to sealing the container for shipment. For information regarding specific sampling procedures and equipment, see Standard Operating Procedures 1-6, 1-11, and 3-1.

All water samples will be placed in a cooled container and sent to the analytical laboratory. Sample analyses will be performed according to methods specified in 40 CFR, Part 136 or other methods approved by EPA. Laboratory methods and reporting limits for all parameters are presented in Table 2. Laboratory results will be supported by sufficient backup data and quality assurance results to enable reviewers to conclusively determine the quality of the data in accordance with the accompanying Quality Assurance Project Plan (QAPP). The analytical report package will include reference to the analytical methods used, detection limits, and quality control data.

Samples must be analyzed in the laboratory within the holding times specified by the lab. For metals (except mercury) the holding time is 6 month. Other holding times are as follows:

Mercury	28 days
Alkalinity and cyanide	14 days
Salinity and sulfate	28 days
Hardness	6 months
TDS and TSS	7 days

If all samples are being shipped together to be analyzed at the same time, then all must be shipped within the lowest holding time, which will generally be 7 days. Samples will always be shipped overnight to prevent ice in the coolers from melting. If the lab is not open the day following shipment, coolers must be kept on ice and shipped on a day when they can be received the following day at the lab.

5.0 Flow Measurement Methods

Discharge (flow) measurements will be conducted in accordance with the measurement procedures adapted for use during the previous Rico site monitoring as well as USGS and USBR standard discharge measurement procedures where applicable. An STI Ultrasonic IRU-5180 automated water level detector has been installed on the St. Louis Tunnel discharge, at the existing Parshall flume. An Ott Orpheus Mini submersible pressure transducer has been installed at the existing Parshall flume at the final ponds system outfall discharge to the Dolores River. These water level detectors are connected to data recorders which will maintain frequent (minimum 2 times daily for an essentially "continuous" record) water level (i.e., stage) data that will be periodically downloaded to a laptop computer. The stage data will be converted to flow values using an appropriate flume-rating table. When monthly water quality samples are collected, flows will aiso be manually measured at the existing Parshall flumes. Water depth measurements will be taken at the appropriate location in the flume. This water depth will then be used to read the flow rate from a flume-rating table. The flow measurements will be recorded in a logbook and the discharges calculated in the office. This information will be utilized to check and calibrate the automated stage measurement installations.

As control of work/safety are critical concerns of AR and the Rico team, obtaining river cross-sections during high flow and winter months is a safety issue. River bed geometry surveys will be conducted during lower flow seasons. Stream sections will be selected with the desired characteristics of parallel flows, smooth streambed with minimal obstructions, a straight channel, and a flat streambed. The river water level will be gauged by survey or reference to a staff gage at the respective stations during high flows and periods of ice cover. The surveyed bed configuration from the previous flow season will be applied to the water level measurement at high discharge or ice cover to estimate flow. The method of measurement will be noted for all data collected.

Flow velocity readings and flowrate calculations will be performed in accordance with Standard Operating Procedures 3-4 and 3-6. In summary, during each monthly water sampling event, velocity readings will be taken at each cross section using a Marsh-McBimey, Inc. Flo-mate model 2000 Portable Flowmeter using the six-tenths depth method. This method uses the velocity at six-tenths of the depth as the mean velocity. This method is generally reliable between depths from 0.3 feet to 2.5 feet. The average velocity will be taken at sub-sections along the cross section, facing upstream. The flow meter will be set to the 5 second fixed period average mode. Each average velocity will be multiplied by the area of sub-section of the cross section to obtain the flowrate for that portion. The sum of these flowrates will represent the total flowrate at that river cross section.

6.0 Report

Water quality and flow measurement results will be provided in a brief summary report on a quarterly basis. The report will present the collected data in a summary table format. Sampling, analysis, measurement, and quality control information will be briefly summarized for easy reference. All data will be maintained in a project database. Copies of field notes, sample collection forms, and analytical reports will be included in the report as appendices. Data will be electronically managed with spreadsheets and will be maintained in electronic data files. Electronic reports and data will be available via FTP site.

TABLE 1
Sampling Location Summary

SITE ID	SITE DESCRIPTION
DR-1	Dolores River above St. Louis settling pond system
DR-2	Dolores River immediately above the St. Louis settling pond system outfall
DR-3	St. Louis tunnel discharge at adit
DR-4	Discharge of Pond 15
DR-5	Discharge of Pond 8
DR-6	St. Louis settling pond system outfall to the Dolores River
DR-7	Dolores River below St. Louis settling pond system outfall
DR-4-SW	Dolores River below Silver Swan
DR-G	Dolores River at USGS gaging station #09165000

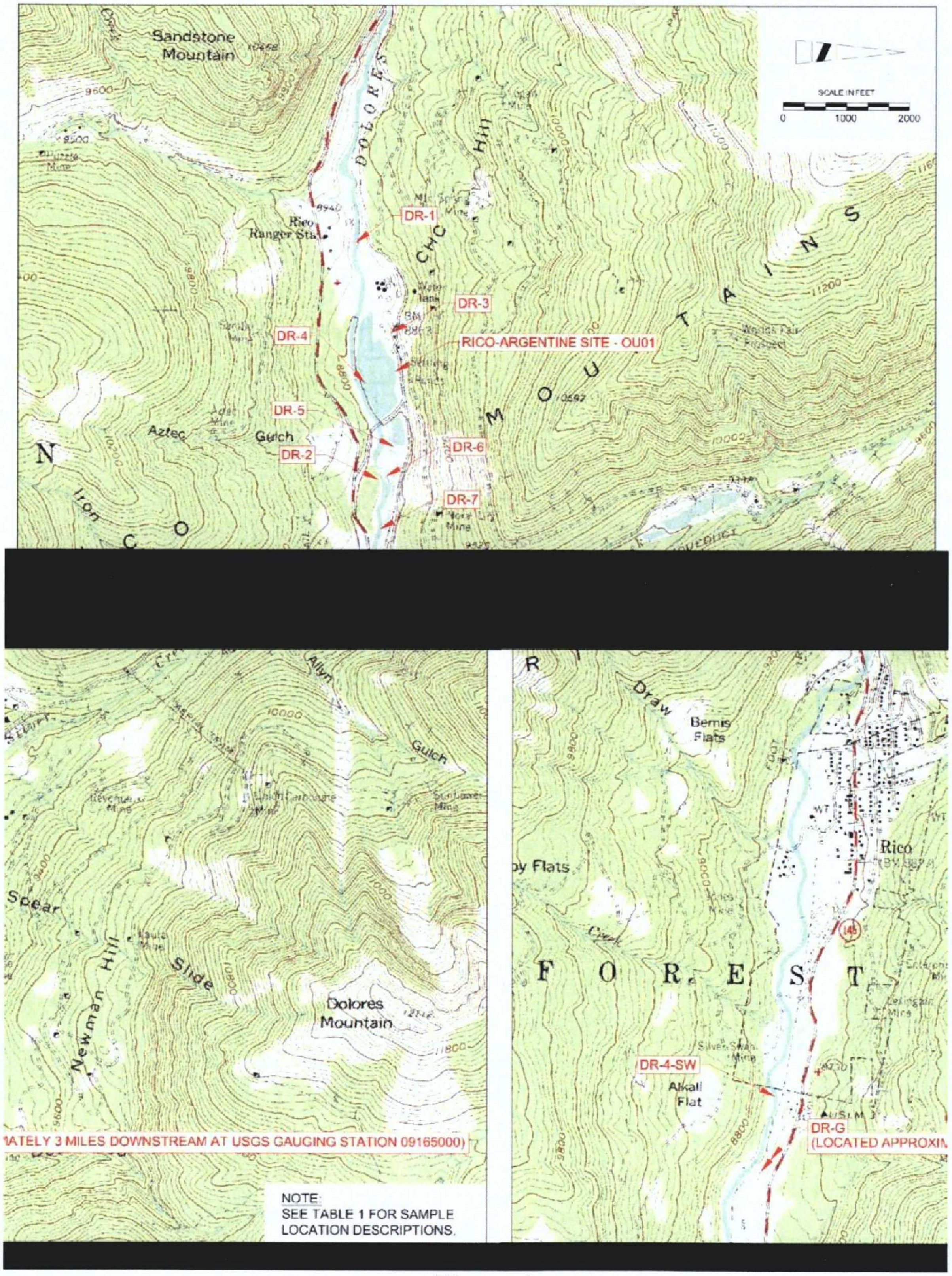

Figure 1
Surface Water Sampling Stations

TABLE 2
Analytical Procedures Summary

PARAMETER	DETECTION LIMIT (MDL)	METHOD
Field Parameters		
pH (s.u.)	+/- 0.01 pH	EPA 150.2
Temperature (□C)	+/- 1° C	Standard Method 2550
Electrical Conductivity (µmhos/cm)	+/- 2% full scale	EPA 120.1
Dissolved Oxygen	+/- 2% Full Scale	SM 4500-OG
Non-Metals		
Alkalinity (mg/L as $CaCO_3$)	RL – 20 mg/L	EPA 310.1
Hardness (mg/L as $CaCO_3$)	RL – 0.5 mg/L	SM 2340 B
Total Dissolved Solids (mg/L as TDS)	RL – 5.0 mg/L	SM 2540C
Total Suspended Solids (mg/L as TSS)	RL – 5.0 mg/L	SM 2540D
Cyanide (µg/L as CN)	RL – 0.005 mg/L	EPA 335.4
Salinity	RL – 6 mg/L	SM 2510B (calculated)
Sulfate (mg/L as SO4)	RL – 1 mg/L	EPA 300.0
Total and Dissolved Metals		
Aluminum (µg/L as Al)	2 µg/L	EPA 200.8
Antimony (µg/L as Sb)	0.07 µg/L	EPA 200.8
Arsenic (µg/L as As)	0.09 pg/L	EPA 200.8
Barium (µg/L as Ba)	0.08 µg/L	EPA 200.8
Beryllium (µg/L as Be)	0.02 µg/L	EPA 200.8
Cadmium (µg/L as Cd)	0.03 µg/L	EPA 200.8
Calcium (µg/L as Ca)	10 pg/L	EPA 200.8
Chromium (ug/l as Cr)	0.25 ug/L	EPA 200.8
Copper (µg/L as Cu)	0.07 pg/L	EPA 200.8
Iron (µg/L as Fe)	4.67 pg/L	EPA 200.8
Lead (µg/L as Pb)	0.05 µg/L	EPA 200.8
Magnesium (µg/L as Mg)	2.5 µg/L	EPA 200.8
Manganese (µg/L as Mn)	0.17 µg/L	EPA 200.8
Mercury (µg/L as Hg)	0.049 µg/L	EPA 245.1
Nickel (µg/L as Ni)	0.07 µg/L	EPA 200.8
Potassium (µg/L as K)	10 pg/L	EPA 200.8
Selenium (ug/l as Se)	0.22 ug/L	EPA 200.8
Silver (ug/L as Ag)	0.25 ug/L	EPA 200.8
Sodium (µg/L as Na)	25 µg/L	EPA 200.8
Thallium (µg/L as Tl)	0.05 ug/L	EPA 200.8

PARAMETER	DETECTION LIMIT (MDL)	METHOD
Vanadium (µg/L as V)	0.05 ug/L	EPA 200.8
Zinc (µg/L as Zn)	2.5 µg/L	EPA 200.8

TECHNICAL STANDARD OPERATING PROCEDURE No. 1-6

SAMPLE CUSTODY AND DOCUMENTATION

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SAMPLE CUSTODY AND DOCUMENTATION

1.0 PURPOSE

The purpose of this procedure is to define the requirements necessary for Sample Custody and Documentation.

2.0 SCOPE

A stringent, established program of sample chain-of-custody procedures shall be followed during field sample collection and handling activities and transfer of the samples to the analytical laboratory.

3.0 REQUIREMENTS

Whenever possible, preprinted labels should be used to ensure that necessary information is retained with the sample.

4.0 REFERENCES

None

5.0 DEFINITIONS

None

6.0 RESPONSIBILITIES

Field Project Leader

The Field Project Leader has overall responsibility for the correct implementation of sampling activities, including review of the sampling plan and any necessary training of the sampling technician(s). The actual collection, packaging documentation (sample label and log sheet, chain-of-custody recorded, Contract Lab reports, etc.) and initial custody of samples will be the responsibility of the sampling technician(s).

7.0 EQUIPMENT

Sample Label

Field Sample Data Sheet

Chain-of-Custody Record

8.0 PROCEDURE

8.1 Sample Label

Each sample shall be labeled, and the following information recorded on the label:

1. Sample identification;
2. Laboratory analyses;
3. Date and time sample was taken;
4. Preservative added; and storage (cooler/ice)
5. Remarks, including pertinent field observations.

8.2 Chain-of-Custody Record

Chain-of-custody (COC) records ensure that samples are traceable from the time of collection until they are received and analyzed by the analytical laboratory. An example COC is attached. If the samples are shipped via commercial shipper, the COC shall be sealed in the sample-shipping container, and the shipping agent or courier is not required to sign the COC. Upon arrival at the lab, the sample custodian checks the custody seals on the sample shipping container, opens the container and signs as receiving the sample.

A sample is in a person's custody if one of the following criteria is met:

1. It is in the person's possession;
2. It is in the person's view after being in possession;
3. It has been locked up to prevent tampering after it was in the person's possession; or
4. It was in the person's possession and was then transferred to a designated secure area.

The COC record is completed and signed by the individual physically in charge of its custody. The sampler is personally responsible for the care and custody of the sample until it is or relinquished to a carrier to transport to the laboratory.

When transferring possession of the samples, the individuals relinquishing and receiving the sample shall sign, date, and write the time of day on the COC record. Samples in separate coolers shall not be included in the same COC record. The COC record is enclosed with the samples in each given cooler after it has been signed by the sampler. The COC record also serves as the laboratory request form.

TECHNICAL STANDARD OPERATING PROCEDURE No. 1-11

PACKAGING AND SHIPMENT OF FIELD SAMPLES

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PACKAGING AND SHIPMENT OF FIELD SAMPLES

1.0 PURPOSE

The purpose of this procedure is to define the requirements necessary for sample packaging and information on chain-of-custody records used in sample transfer. Site specific deviations from the procedures outlined in this document must be approved by the Project Manager or the Client Project Manager.

2.0 SCOPE

This procedure applies to the packaging, shipping and documentation of samples being transferred from the field to the laboratory for analysis.

3.0 REQUIREMENTS

Careful packaging, shipping and documentation are necessary to insure that all samples received are undamaged and authentic.

Sample packaging is to be in accordance with ultra clean sampling procedures defmed in EPA method 1669.

4.0 REFERENCES

HAZWRAP, July 1990. Quality Control Requirements for Field Methods, DOE/HWP-69/R1.

HAZWRAP, July 1988. Requirements for Quality Assurance of Analytical Data, DOE/HWP-65, Rev. 0, July 1988.

U.S. Department of Transportation, 1983. Hazardous Materials Regulations, 49 CFR 171-177.

United States Environmental Protection Agency, 1984. User's Guide to the Contract Laboratory Program, Office of Emergency and Remedial Response, Washington, DC.

USAEC, May 1993. U.S. Army Environmental Center Guidelines for Implementation of ER 1110-1-263 for USAEC Projects.

USATHAMA, January 1990. U.S. Army Toxic and Hazardous Materials Agency Quality Assurance Program, USATHAMA PAM 11-41.

EPA Method 1669, Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels, July 1996, Office of Water Engineering and Analysis Division, Washington, DC.

5.0 DEFINITIONS

Carrier - A person or firm engaged in the transportation of passengers or property.

Chain-of-Custody Record Form - A Chain-of-Custody Record Form is a printed form that accompanies a sample or group of samples as custody of the sample(s) is transferred from one custodian to the subsequent custodian. Chain-of-Custody Record Form is a controlled document. One copy of the form must be retained in the project file.

Custodian - The person responsible for the custody of samples at a particular time, until custody is transferred to another person (and so documented), who then becomes custodian. A sample is under your custody if:

- You possess the sample.
- It is in your view, after being in your physical possession.
- It was in your physical possession and then you locked it up to prevent tampering.
- You have designated and identified a secure area to store the sample.

Environmental Sample - A low concentration sample typically collected offsite and not requiring DOT hazardous waste labeling as a high hazard sample.

Packaging - The assembly of one or more containers and any other components necessary to insure that all samples received are undamaged and authentic.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the point and time that it was collected.

Clean Hands – All operations involving contact with the sample bottle and transfer of the sample from the sample collection device to the sample bottle are handles by the individual designated as "clean hands".

Dirty Hands – All operations involving preparations of the sampler (except the sample container itself), operation of any machinery, and for all other activities that do not involve direct contact with the sample.

Holding Time – The time from the moment the sample is taken from the source until analysis is performed on that sample in the lab.

6.0 RESPONSIBILITIES

Field Project Leader - Responsible for determining that samples are properly packaged and shipped, and for determining that the chain-of-custody procedures are implemented from the time the samples are collected to their release to the shippers.

Field Samplers - Responsible for implementing the packaging and shipping requirements and for initiating the chain-of-custody records until they are relinquished to another custodian, to the shipper, or to the carrier.

7.0 EQUIPMENT

1. Bubble Pack
2. Sampling Gloves
3. Reclosable Plastic Bags
4. Permanent Felt Tip Marker
5. Shipping Coolers
6. Ice or Blue Ice.
7. Ziploc plastic bags (appropriate size for samples).

8.0 PROCEDURE

8.1 Sample Packaging and Shipping

Samples collected for shipment from a site should be classified as environmental samples and in general, are not expected to be grossly contaminated with high levels of hazardous materials.

Upon arrival at the sampling site, one member of the two-person sampling team is designated as "dirty hands"; the second member is designated as "clean hands." This is in accordance with EPA method 1669.

8.2 Environmental Samples

8.2.1 Packaging

Environmental samples may be packaged as follows:

- Place each sample within a Ziploc bag, then place that sample with bag into a second Ziploc bag. In accordance with EPA Method 1669 "clean hands, dirty hands" method. (to prevent sample labels from becoming saturated due to ice within the sample cooler)
- Place samples in a cooler.
- Pack with enough cushioning materials to minimize the possibility of container breakage.
- If sample preservation methods call for it, place ice which has been bagged in ziplock bags (or blue ice) in the cooler to maintain the proper preservative temperature of 4 degrees C
- Seal cooler with packing tape or duct tape if cooler is being shipped though commercial shipper to laboratory.
- Always ship samples overnight in order to prevent ice in coolers from melting before reaching the lab.

8.3 Holding Times

Samples must be analyzed in the laboratory within the holding times specified by the lab. For metals (except mercury) the holding time is 6 month. For mercury, h's 28 days; for alkalinity and cyanide analysis, it's 14 days; for sulfate and salinity, it's 28 days; for hardness, it's 6 months; and for TDS and TSS, the holding time is 7 days. If all samples are being shipped together to be analyzed at the same time, then all must be shipped within the lowest holding time, which will generally be 7 days.

8.4 Chain-of-Custody

See SOP 1-6 (Sample Custody and Documentation) for Chain of Custody guidelines.

TECHNICAL STANDARD OPERATING PROCEDURES No. 2-9

FIELD WATER QUALITY MEASUREMENTS

FIELD WATER QUALITY MEASUREMENTS

1.0 PURPOSE

The purpose of this procedure is to define the requirements for the standard operating procedure of taking field water quality measurements, including pH, temperature, dissolved oxygen, and conductivity.

2.0 SCOPE

This procedure applies to the calibration, operation, and maintenance of an EXTECH DO610 combo meter kit, which measures pH, temperature, conductivity and dissolved oxygen (DO).

3.0 REQUIREMENTS

Electrical conductance of a substance is its ability to conduct an electrical current. Chemically pure water has a low electrical conductance; while water that contains dissolved inorganic solids (chloride, phosphate, etc.) has a higher electrical conductance. Consequently, the greater the amount of dissolved solids in groundwater or surface water the greater the water's electrical conductivity.

4.0 REFERENCES

EXTECH Instruments DO610 ExStik II DO/pH/Conductivity Kit Instruction Manual

5.0 DEFINITIONS

None.

6.0 RESPONSIBILITIES

Field Project Leader (FPL)

The FPL is responsible for overseeing the sampling activities and ensuring the proper calibration and maintenance of field water quality instruments.

7.0 EQUIPMENT

The instruments to be used for testing water quality in the field include the following:

- EXTECH DO610 DO/pH/Conductivity Meter Kit

8.0 PROCEDURE

The manufacturer's instructions included with the units are to be followed for initial and continuing calibration, and maintenance of the instruments. Instruction manuals are to be on-site with the instruments and are to be reviewed by the field personnel at the beginning of the sampling event. Instrument calibration of pH and conductivity should be done with standards that bracket the expected range ofımeasured values.

bıstruments are to be calibrated daily at or before the first sampling location of the day. Calibration information is to be recorded in the field log book.

Specific instructions on operating the equipment properly are given in detail in the DO610 combo kh instmction manual, which will always accompany the equipment.

TECHNICAL STANDARD OPERATING PROCEDURE No. 3-1

SURFACE WATER AND SEDIMENT SAMPLING

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SURFACE WATER AND SEDIMENT SAMPLING

L0 PURPOSE

The purpose of this procedure is to define the requirements necessary for surface water and sediment sampling. This SOP presents a discussion of the recommended methods and frequency of sample collection as a guide to developing site-specific sampling programs. This procedure describes the methods and equipment commonly used for collecting environmental samples of surface water and sediment samples for either on-site examination and testing, or for laboratory analysis. Site-specific deviations from the procedures outlined in this document must be approved by the AECI Project Manager or the Client Project Manager prior to initiation of the sampling activity.

2.0 SCOPE

Surface water and sediment sampling is applicable to almost any site that has surface drainages on it or located hydraulically downgradient from it.

3.0 REQUIREMENTS

Many factors must be considered in developing a sampling program for surface water or sediments, including study objectives; accessibility; site topography; flow, mixing, and other physical characteristics of the water body; point and diffuse sources of contamination; and personnel and equipment available to conduct the study. For waterbome constituents, dispersion depends on the vertical and lateral mbxing within the body of water. For sediments, dispersion depends on bottom current or flow characteristics, sediment characteristics (density, size) and geochemical properties. Ultra clean methods will be followed for sampling activities.

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EPA Method 1669, Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels, July 1996, Office of Water Engineering and Analysis Division, Washington, DC.

5.0 DEFINITIONS

Environmental Sample - Low concentration sample typically collected offsite and not requiring DOT hazardous waste labeling as a high hazard sample.

Sediment – Sediment generally refers to solid material such as sand, silt, clay, and gravel, which is deposited by fluvial or alluvial processes.

Clean Hands – All operations involving contact with the sample bottle and transfer of the sample from the sample collection device to the sample bottle are handles by the individual designated as "clean hands".

Dirty Hands – All operations involving preparations of the sampler (except the sample container itself), operation of any machinery, and for all other activities that do not involve direct contact with the sample.

6.0 RESPONSIBILITIES

Project Manager

The Project Manager is responsible for the selection of the appropriate methodology, technique and field procedure for conducting the sampling.

Field Project Leader (FPL)

May be an AECI employee or contractor who is responsible for overseeing the sampling activities. The FPL is also responsible for checking all work performed and verifying that the work satisfies the specific tasks outlined by this SOP and the Project Plan.

7.0 EQUIPMENT

1. Sampling Bottles (treated with preservatives, if necessary)
2. Specific Conductivity Meter
3. Dissolved Oxygen Meter
4. Turbidity Meter
5. Oxidation-Reduction Meter
6. pH Meter
7. Thermometer or temperature meter
8. Stainless Steel Bowl and Spoon
9. Stainless Steel Hand Augers, Shovel, or Spoon
10. Filtering Equipment (if analyzing for metals in water)
11. Peristaltic Pump
12. Decontamination Equipment and Supplies
13. Sampling nontalc gloves
14. Ziploc bags (appropriate size)

8.0 PROCEDURE

8.1 General Procedures for Surface Water Sampling

- In order to meet the sample handling and preservation requirements, several separate collection bottles will be used at each location, and together will comprise the "sample." The sample will consist of 5 bottles, consisting of two 250-mL acidified (nitric acid) polyethylene bottles (one non-filtered for total metals and hardness analysis and the other filtered for dissolved metals analysis), one 250-mL polyethylene bottle containing sodium hydroxide (NaOH) preservative for cyanide analysis, one 250-mL non-acidified polyethylene bottle to be used for salinity analysis, and one 500-mL non-acidified polyethylene bottle for the remaining inorganic analysis.

- Upon arrival at the sampling site, one member of the two-person sampling team is designated as "dirty hands"; the second member is designated as "clean hands." This is in accordance with EPA method 1669 for ultra clean sampling procedure.
- Care should be taken to insure that the grab sample is collected from a point that appears well-mixed, both laterally and vertically, and in the mid-stream of the flow. Backwater or stagnant areas should be avoided.
- If possible, the sampler should stand on the banks of the stream, avoiding sloughing into the stream channel. However, if it is not possible to reach a well-mixed, mid-stream flow from the banks, the sampler should wade into the stream wearing clean waterproof boots. Feet should be placed downstream of the collection point, with the sampler facing upstream. Care should be taken not to dislodge or stir up bed material or fine settled material coating the bed material.
- The lab-certified, pre-cleaned raw water bottle, which does not contain preservatives, may be used as a collection container for all sub-samples in the set. Pre-preserved bottles should not be immersed in the stream channel.
- The sampler should wear a clean, new pair of disposable gloves while lowering the collection container into the stream. The bottle mouth should face upstream, and be held under the surface. Depending upon the depth of the flow column, the bottle can be lowered below the water surface to mid-depth, but not so far as to collect or stir up bottom sediments.
- The collected water should be carefully poured into the acidified bottle designated for total metals without overflowing.
- Another batch of water should be similarly collected in the raw water bottle, from which a filtered sample for dissolved metals can be obtained. The peristaltic pump equipped with new, disposable tubing is used to pump water from the raw water bottle through the new, disposable 0.45 micron filter, and into a second acidified bottle for dissolved metals analysis. Alternately, the intake tubing for the pump may be lowered into the stream flow and the water pumped directly through the filter and into the acidified bottle for dissolved metals analysis.
- After collection at each sample site, the tubing and filter should be discarded.
- The raw water bottle used for collection purposes is then refilled and sealed for the remaining analytical sample.

8.2 General Procedures for Sediment Sampling

The following section outlines commonly used procedures for collecting surface water and sediment samples. Criteria for choosing the correct piece of sampling equipment is also covered in this section. All sampling equipment should be cleaned and decontaminated prior to use in accordance with SOP 1-9.

- In general, whenever sampling surface water and sediments from the same location, the surface water samples should be collected first and sediments second to minimize collection of sediment with the water samples.
- In general, the stream flow measuring is perfonned after the surface water and sediment samples have been collected.
- Protective clothing and proper equipment specified in the site-specific Heahh and Safety Plan should be worn and used.
- The sampling sequence shall begin at dovmstream locations and progress upstream to prevent cross-contamination from one location to another.
- Prior to sampling sediments in a stream, the sampling devise shall be rinsed with stream water at a point downstream from the sampling location. Twigs, leaves, pebbles, and debris that are not integral components of the matrix of interest must be removed by the sampling team. Prior to sampling sediments in a pond or lagoon, the sampling devise shall be triple rinsed with water near the sampling point. However, caution must be exercised to avoid disturbing the sediments at the sampling point by the rinsing activities.

The sediment sample should be mixed and homogenized in a stainless-steel bowl prior to placement in the sample container. Duplicates and split samples shall be collected from the same bowl as the sample.

8.3 Surface Water Collection Techniques

8.3.1 Dip Sampling

A dip or grab sample should be collected over a period of not exceeding 15 minutes. Water is often sampled by filling a container, either attached to a pole or held directly, from just beneath the surface of the water (i.e., a dip or grab sample).

8.3.2 Weighted Bottle Sampling

A grab sample can also be taken using a weighted holder that allows a sample to be lowered to any desired depth, opened for filling, closed, and retumed to the surface. This allows discrete sampling with depth. Several of these samples can be combined to provide a vertical composite. Alternatively, an open bottle can be lowered to the bottom and raised to the surface at a uniform rate so that the bottle collects sample throughout the total depth and is just filled on reaching the surface. The resuhing sample using either method will roughly approach a depth-integrated sample.

A closed weighted bottle sampler consists of a stoppered glass or plastic bottle, weight and/or holding device, and lines to open the stopper and to lower or raise the bottle.

8.3.3 Pumps

A peristaltic pump may be used both for collection of a surface water sample and to pump water through a filter for dissolved metals analytical sample.

Tubing used for the pump shall be nonreactive (preferably Teflon® or Tygon®). The tubing shall be disposed of after one use.

When sampling, the tubing is weighted and lowered to the desired depth. The sample is then obtained by operation of the pump.

8.4 Underwater Sediment Collection Options

Sediment samples are generally collected at the same locations as the water samples. If only one sediment sample is to be collected, the site shall be approximately at the center of the water body. This is particularly true for reservoirs that are formed by the impoundment of rivers or streams. Generally, the coarser grained sediments are deposited near the headwaters of the reservoir. Bed sediments near the center will be composed of fine-grained materials which may, because of their lower porosity and greater surface area available for adsorption, contain greater concentrations of contaminants. The shape, flow pattern, depth distribution, and water circulation patterns must all be considered when selecting sediment, sampling sites. In streams, areas likely to have sediment accumulation (i.e., bends, behind islands or boulders, quiet shallow areas or very deep, low-velocity areas) shall be sampled while areas likely to show net erosion (i.e., high-velocity, turbulent areas) and suspension of fine solid materials shall be avoided.

Chemical constituents associated with bottom material may reflect an integration of chemical and biological processes. Bottom samples reflect the historical input to streams, lakes, and estuaries with respect to time, application of chemicals, and land use. Bottom sediments, especially fine-grained material, may help act as a sink or reservoir for adsorbed heavy metals, even if the water column concentrations are below detection limits. It is important to minimize the loss of low-density "fines" during any sampling process.

8.4.1 Scoop Sampler

A scoop sampler may consist simply of a stainless steel spoon if the water is shallow enough (generally less than 8 inches deep) or a pole to which a jar or scoop is attached for deeper water. The pole may be made of bamboo, plastic, wood, or aluminum, and be either telescoping or of fixed length. A stainless steel scoop or glass jar at the end of the pole is usually attached using a clamp.

If the water body can be sampled from the shore or if it can be waded, the easiest and "cleanest" way to collect a sediment sample is to use a scoop sampler. This reduces the potential for cross-contamination. This method is accomplished by reaching over or wading into the water body and, while facing upstream (i.e., into the current), scooping the sample along the bottom in the upstream direction. It is very difficuh not to disturb fine-grained materials of the sediment-water interface when using this method.

8.4.2 Core Samplers

Core samplers are used to sample vertical columns of sediment. They are useful when a historical record of sediment deposition is desired, for they preserve the sequential layering of the deposit. Also, the sample is withdrawn intact, permitting the removal of only those layers of interest. Core liners manufactured of glass, Teflon®, brass, or stainless steel. In addition, samples are easily delivered to the lab for analysis in the tube in which they are collected. The disadvantage of coring devices is that a relatively small surface area and sample size is obtained necessitating repetitive sampling to obtain large amounts of sample needed for some analyses.

Many types of coring devices have been developed to address varying depths of water from which the sample is to be obtained, the nature of the bottom material, and the length of the core to be collected. In shallow wade-able waters, the direct use of a core liner is recommended. The liner material shall be chosen based upon the analytical parameters required.

Core sampler tubes or liners shall be approximately 12 inches long since only recently deposited sediments, eight inches or less, are to be sampled. Soft or semi-consolidated sediments such as mud and clays have a greater adherence to the inside of the tube and thus can be sampled with larger diameter tubes. However, because coarse or unconsolidated sediments such as sand and gravel will tend to fall out of the tube, a small diameter is required. A tube about 2 inches in diameter is usually sufficient. The wall thickness of the tube shall be about 1/3 inches for either Teflon® or glass. The end of the tube may be tapered by filing it down to facilitate entry of the liner into the substrate.

8.5 Dry Channel Sediment Collection

Sediment samples collected from dry channels shall be collected according to the protocols listed in SOP 5.2 – Soil Sampling. Sediment collected from dry channels shall be collected from separate depths of 0-2 inches and 2-6 inches.

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STREAM FLOW MEASUREMENTS

1.0 PURPOSE

The purpose of this procedure is to describe methods, sequence of operations, and equipment necessary to determine the cross-sectional area and flow of a stream. . Site-specific deviations from the procedures outlined in this document must be approved by the AECI Project Manager or the Client Project Manager prior to initiation of the sampling activity.

2.0 SCOPE

An essential part of any remedial investigation is knowing the quantities of stream flow across the site being investigated. This knowledge serves as an aid in determining proper remedial actions. Stream flow measurement is to be conducted concurrently with stream sampling. The flow should be measured immediately after the water quality sample is collected and in the same location.

3.0 REQUIREMENTS

Since the physical characteristics that streams exhibit vary widely, it is necessary to present several methods and techniques that can be used to calculate channel areas and flow rates.

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5.0 DEFINITIONS

Flow (or volumetric flow rate) - The volume of water that passes through a cross-sectional plane in some unit of time.

Flume - An artificial channel used for constricting the flow of water in order to promote laminar flow for the purpose of measuring flow volume.

Stage - The height of a water surface above an arbitrarily established datum plane.

Weir - A levee or dam-type structure containing a notch through which the flow of water can be measured and regulated.

6.0 RESPONSIBILITIES

Project Manager

The Project Manager is responsible for the selection of the appropriate methodology, technique and field procedure for conducting the flow measurements.

Field Project Leader

The Field Project Leader is responsible for the execution of the field test to determine flow in an open channel. The Field Project Leader is also responsible for inspection of equipment to ensure its adequacy for performance, and preparation of the site.

7.0 EQUIPMENT

Equipment required will vary depending upon method of cross-sectioning and flow measuring selected.

8.0 PROCEDURE

8.1 General

The discussion below addresses the various methods and techniques used to measure cross-section and stream velocities with respect to the velocity-area open channel technique of stream flow measurement. These techniques should be applied whenever stream gauging information is not available. When possible, stream gauging station information will be utilized because real time flow information can be obtained from the authority responsible for the station.

The most common method of open channel flow determination is the velocity-area method. In this method, a flow or discharge measurement is computed as the summation of the products of partial areas of the flow cross-section and their respective average velocities as determined by a current meter. This calculation is represented by the formula:

$Q = \Sigma V * \Sigma A$ where:

Q = total discharge,

A = individual partial cross-sectional area

V = corresponding mean velocity normal to the partial area

Σ = summation of individual measurements

Altemately, the portable control section method may be used, which uses a pre-calibrated control structure such as a flume or weir. These methods are discussed below.

8.2 Cross-Sectional Area Determination

8.2.1 Width Determination

Width determination for narrow, shallow streams and brooks is accomplished by a simple tape measurement; however, for large streams, altematives may be required. Bridges are convenient avenues across which measurements can be made. An equally acceptable method of determining width will be by transit and stadia survey techniques.

8.2.2 Depth Determinations

Most often, depth measurements are taken directly with a measured rod or sounding weight. The mass of the weight suspended at the end of the tape should be sufficient to keep the tape essentially vertical. For high velocity streams or excessively deep channels, a sonic sounder is most appropriate, since some can be adapted to produce a continuous strip chart profile of the channel depth.

8.3 Velocity/Flow Determinations

As a general practice, the actual measurement of depth, width and velocity would normally occur concurrently. When flow measurement is to be performed concurrently with analytical sampling, the analytical samples are to collected prior to measuring the flow in order to avoid compromising the sample with stream sediment. The main parameters to be collected for open channel flow determinations will be cross-sectional area and stream velocity.

8.3.1 Current Meters

Current meters provide a quick and relatively accurate method of determining flow under existing site condhions. They are generally not used for long-term determinations. There are many types of current meters: mechanical, electrical, vertical shaft, and horizontal shaft. The types preferred for open channel stream measurement are those which have a vertical shaft. The basic concept of a current meter is that a rotating element at the end of the vertical shaft (or, in some cases, stationary electrodes) is submerged beneath the stream's surface where the flow of water rotates the element (or passes between the electrodes). The speed of rotation of the element (or flow between the electrodes) measured directly by the current meter which is then correlated to stream flow velocity through the meter's own electronic circuitry or by graphs or charts which accompany the instrument. Speed is normally measured in meters/second or feet/second. Current meters will generally measure flow down to 0.03 meters/sec (0.1 ft/second). Current meters that use electrodes may be utilized for measuring streams that have weedy growths emanating from the stream bottom which would affect the rotation element. The depth to which current meters can be used will only be limited by the ability to hold the unit rigid at depth. Once a current meter value is taken, the measurement will be averaged with other measurements taken along a vertical transect of the stream at that point to determine the mean velocity along that vertical transect. In a wide sfream, several vertical fransects can be constructed such that less than 10 percent of the volume of the stream will be represented by each transect. The mean stream velocity can be calculated as the average of the individual average vertical velocities of each transect, with each average velocity weighted by the cross-sectioned area of the stream that it represents.

The Standard Operating Procedures regarding current meters for the IS&R/Carr Fork site shall follow all guidelines as discussed in SOP 3-6, "Streamflow Measurement with Portable Meter."

8.3.2 Flumes

A considerably more sophisticated method of determining sfream flow is through the installation of artificial, pre-calibrated control structures such as a flume. A flume is basically a constricted flow structure that provides a uniform cross-section for measurement of flow. Flow should be determined within the superficial section within the throat of the constriction. For a detailed discussion of weirs and flumes, see U.S. Geological Survey (1977), Volume I, Chapter 1, pp. 1-65 to 1-77.

A flume is a specially shaped, open channel flow section which restricts the channel area and/or changes channel slope. This configuration results in an increased velocity and change in the level of the liquid flowing through the flume. The volumetric flow through the flume is determined by measuring the liquid level in the flume at a gage point, usually at some point downstream from the flume inlet. The liquid level/ flow rate relationship for a flume is defined by either test data (calibration curves) or by an empirically derived formula. This relationship s typically supplied by the manufacturers. Flumes are used when hydraulic head loss through the channel must be minimized, sediments or solids are present in the stream flow, and stream flow rates vary.

The selected flume location for open channel flow measurement shall be accessible in all weather conditions with an inlet approach that is level, straight, and of sufficient length to allow for smooth and uniform flow. In all cases, manufacturer's recommendations for installation, calibration, and instrumentation shall be followed.

To measure the quantity of flow using a flume, the depth of flow from the water surface to the flume floor is obtained at a gage point in the converging section of the flume structure. Liquid levels in the flume relate directly to flow quantity by a mathematical formula specific to a particular flume geometry. In all cases, the manufacturer will supply the flow quantity formula to be used.

For fluid flow height measurement, a staff gauge shall be permanently mounted in the converging section of the flume according to manufacturer's recommendations. If manual flow levels are used, several levels shall be read. All data shall be recorded in the bound field logbook (see SOP 1-5).

If fluid levels in a flume are measured electronically, an ultrasonic water-level transmitter or equivalent device shall be used. This device will measure the liquid level in the flume and provide output signals to a data recorder for flow rate and volumetric flow totals. If an ultrasonic transmitter is used, it shall be installed, calibrated, and maintained according to manufacturer's recommendations.

8.3.3 Weirs

A weir is a dam or obstruction placed across an open channel with an opening on top through which the measured liquid flows. Stream flow should be determined by measuring the height of flow through the weir, which is a function of potential energy behind the overfall. Weirs are classified according to the shape of the weir plate opening. The most common types of weirs are the rectangular weir, the V-notch weir, and the trapezoidal weir.

The volumetric flow through a weir may be determined by measuring the liquid level at a prescribed distance upstream from the weir plate. Characteristic head versus flow relationships are governed by the geometry of the weir plate. All level measurements are made relative to the crest elevation. Weirs are not suitable for flat-sloped channel installations where head loss must be considered and for water carrying excessive solid materials or silt.

To measure the quantity of flow using a weir. the head or vertical distance from the crest of the weir plate to the liquid surface is measured in the pool upstream from the crest. Once the head is known, the quantity of flow can be determined using the known head-flow rate relationship of the particular weir (i.e., V-notch, rectangular. etc.).

For the head measurement, a staff gage shall be permanently mounted in the pool upstream from the weir crest. If manual head measurements are used, several levels shall be read. All data shall be recorded in the bound field logbook (see SOP 1-5).

If head levels in a weir are measured electronically, an ultrasonic water-level transmitter or equivalent device shall be used. This device will measure the liquid level and provide output signals to a data recorder for flow rate and volumefric flow totals. If an ultrasonic water-level transmitter is used, it shall be installed, calibrated, and maintained according to manufacturer's recommendations.

8.3.4 Instrumentation

Flow measurements can be recorded either manually or electronically. A flow totalizer for recording the quantity of water shall be installed at all electronically instrumented measurement locations.

All flow recording instruments shall be protected from weather and vandalism, and shall be checked on a regular basis to ensure the data recorder (totalizer or chart) is functioning properly. Manually recorded flow quanthies shall be entered in the bound field logbook. Original charts from electronically recorded flow quantities shall be kept in central files for future reference.

8.3.5 Calculations

Calculations related to flow measurement shall be completed using established procedures as listed in SOP 3-6. Results from calculations shall be checked and verified before use or permanent storage.

8.3.6 Records

All records associated with flow measurement including charts, graphs, and field logs, shall be placed in a calculation brief format, checked, and verified prior to use or permanent storage.

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STREAMFLOW MEASUREMENT WITH PORTABLE METER

1.0 PURPOSE

The objective of streamflow measurement is to determine the discharge (volume/time = flow velocity x area) by dividing a representative stream cross section into smaller sections, measuring flow velocity and area of each smaller section, and summing the measured discharge of each smaller section to provide the total stream discharge. This SOP is to be used by employees of AECI and/or contractors/subcontractors. Site-specific deviations from the procedures outlined in this document must be approved by the AECI Project Manager or the Client Project Manager prior to initiation of the sampling activity. This SOP relates directly to SOP 3-4: Stream Flow Measurements, and acts as a subsection of that SOP. Field team shall be familiar with Both SOPs.

2.0 SCOPE

An essential part of any remedial investigation is knowing the quantities of stream flow across the site being investigated. This knowledge serves as an aid in determining proper remedial actions.

3.0 REQUIREMENTS

None

4.0 REFERENCES

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5.0 DEFINITIONS

Flow (or volumetric flow rate) - The volume of water that passes through a cross-sectional plane in some unit of time.

6.0 RESPONSIBILITIES

Project Manager

The Project Manager is responsible for the selection of the appropriate methodology, technique and field procedure for conducting the flow measurements.

Field Project Leader (FPL)

May be an AECI employee or contractor who is responsible for overseeing the sampling activities. The FPL is also responsible for checking all work performed and verifying that the work satisfies the specific tasks outlined by this SOP and the Project Plan.

7.0 EQUIPMENT

1. Portable flow meter (Marsh-McBimey Model 2000 or equivalent)
2. Flow meter wading rod, calibrated in .1-foot intervals
3. Measuring tape or equivalent

8.0 PROCEDURE

1. Select a stream section (metering section) where flows are mostly parallel, there are no sharp turns in water direction, and the bottom is reasonably smooth; the velocity measurements will be more accurate. The metering section can be smoothed by reshaping the edges, removing rocks from the bottom, removing aquatic weeds, etc. It is usually not possible to satisfy all of these conditions. Select the best possible metering section using these criteria.
2. Record the metering section location, time date, recorder and other pertinent information in the field log book.
3. Set a measuring tape or equivalent across the metering section as perpendicular to the flow as

possible. Anchor both ends securely to wooden stakes, trees, rocks, etc. This placement will allow accurate placement of the flowmeter across the metering section.

4. Divide the metering section into sections. For streams wider than 5 feet, not more than 10% of the flow can be included in any one vertical section.
5. Velocity measurements begin at the initial point at either the left or right bank of the metering section. The initial point is usually defined as the measuring tape reading at the contact of the water line and stream bank. However, in some cases, there may be no flow for some distance from the stream bank, due to stagnant water or backwater effects. In such a case, the initial point begins where positive flow can be measured. Record the initial point reading in the field log book.
6. Attach the flow meter probe to the wading rod. Tum on the flow meter.
7. Position the flow meter in the center of the first vertical section.
8. Measure the water depth using the wading rod. Record the total water depth in the field log book. Water depth is determined from calibrations on the wading rod. Three marks signify 1-foot intervals, two marks signify 0.5-foot intervals and one mark signifies 0.1-foot intervals. Read stream depths ignoring the "pile-up" effect of water on the upstream side of the wading rod.
9. Position the flow meter to six-tenths of the total depth (from the surface) of the vertical section and pointing directly into the flow. This depth can be obtained using the wading rod by aligning the total depth marks on the rod to the 0.6 mark on the wading rod handle. Allow the flow meter to stabilize for 10 seconds. Measure the velocity for 30 seconds. Record this value in the field log book. This value is the velocity used to determine the flow within the vertical section being measured.

   This method will be best utilized when the depth of the stream is less than 0.8 meters (2.6 feet) but greater than 0.1 meters (0.3 feet). In this method, each measurement within each vertical section should be taken three times and the result averaged to determine the mean velocity. This method will reduce the effects of aberrant measurements.
10. Calculate the area (feet squared) of vertical section by multiplying the width by the total depth.
11. Calculate the flow (cubic feet per second) of each vertical section by muhiplying the area by the average velocity.
12. Calculate the total flow of the metering section by summing all the flows of each vertical section. Record this value in the field log book.

9.0 PRECAUTIONS

The limit for wading is set by health and safety considerations of the field personnel. The amount of water that can be waded safely varies slightly with each individual, but is principally a function of velocity, depth, and substrate stability and slickness. Field personnel shall not take chances in gauging streams that cannot be easily waded.

The wading position taken by the field personnel when making stream flow measurements can affect the velocity of the water passing the flow meter probe. The best position to stand in the stream is approximately 18 inches or more to the side of the wading rod and flow meter probe. This allows the water to flow around the flow meter freely without the potential back water effects a downstream wader may cause.

10.0 QUALITY CONTROL

Because flow is not a direct measurement (velocity, depth, width, and area are measured first), the accuracy of the method cannot be determined. With selection of good cross-sections, and careful measurements of depth and velocity, measured flow should be within ±10 percent of true flow.

Precision of the method (and technique of the investigator) can be determined by measuring total flow several times along the same cross-section.

Peak instrument performance can be ensured by conducting the periodic maintenance tasks detailed in the Instruction Manual. These tasks include cleaning of the probe, checking the meter zero, and checking the condition of batteries.

11.0 SPECIAL INSTRUCTIONS

Because total flow determination in an open channel is a summation or integration process, the overall accuracy of the measurement is generally increased by increasing the number of partial cross-sections. Generally, 10 to 20 cross-sections are adequate depending on the variability and complexity of the cross-sectional shape and flow patterns. With a smooth cross-section and good velocity distribution, or with narrow stream channels, fewer sections may be used.

Occasionally, flows are not perpendicular to the established cross section for its entire width. If high or low flows change flow patterns at an established cross-section, consideration should be given to temporarily or permanently moving a cross-section rather than using a substandard, established one.